

Southern wide very low-mass stars and brown dwarfs in resolved binary and multiple systems

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ABSTRACT

The results of the Koenigstuhl survey in the Southern Hemisphere are presented. I have searched for common-proper motion companions to 173 field very low-mass stars and brown dwarfs with spectral types $> M5.0V$ and magnitudes $J \lesssim 14.5$ mag. I have measured for the first time the common-proper motion of two new wide systems containing very low-mass components, Koenigstuhl 2 AB and 3 A–BC. Together with Koenigstuhl 1 AB and 2M0126–50AB, they are among the widest systems in their respective classes ($r = 450\text{--}11\,900$ AU). I have determined the minimum frequency of field wide multiples ($r > 100$ AU) with late-type components at $5.0 \pm 1.8\%$ and the frequency of field wide late-type binaries with mass ratios $q > 0.5$ at $1.2 \pm 0.9\%$. These values represent a key diagnostic of evolution history and low-mass star and brown-dwarf formation scenarios. Additionally, the proper motions of 76 field very low-mass dwarfs are measured here for the first time.

Subject headings: stars: low mass, brown dwarfs – stars: binaries: visual – stars: formation – stars: individual: HD 221356, 2MASS J23310161–0406193AB, LP 655–23

1. Introduction

Very low-mass (VLM) dwarfs have masses of about one tenth of the Solar mass or less, and spectral types later than M5 V ($T_{\text{eff}} \lesssim 3000$ K). Many of them are found in binary and multiple systems with a large variety of separations and mass ratios. Proxima Centauri (M5.5V), with a mass of $0.11 \pm 0.02 M_{\odot}$, is the nearest and most famous example of a VLM

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dwarf in a multiple system. Given its large separation to α Cen AB, of more than 15 000 AU, Proxima is close to be gravitationally unbound (Wertheimer & Laughlin 2006 and references therein). The binary BL Ceti + UV Ceti (M5.5V+M6.0V), the sixth closest star system to the Sun, is on the contrary a tight binary separated by only ~ 5 AU (Heintz 1987). There are even some VLM field dwarfs that are both tight binaries and companions to more massive stars, e.g. ϵ Indi BC (T1V+T6V) at ~ 1500 AU to the nearby K4.5V star ϵ Indi A (Scholz et al. 2003; McCaughrean et al. 2004).

The systems containing VLM components can be dichotomized into two groups according to their mass ratios. One group comprises systems with mass ratios $M_2/M_1 \equiv q < 0.5$, and includes from radial-velocity, transit and microlensing exoplanet candidates to late-type star and brown-dwarf companions to FGKM-type stars detected in direct image (see The Extrasolar Planets Encyclopaedia and Burgasser, Kirkpatrick & Lowrance 2005 for comprehensive compilations of planetary and late-M-, L-, and T-type companions to stars, respectively). The other group contains late-type stars and brown dwarfs in double systems with mass ratios $q > 0.5$. Throughout this work, I will refer to them as equal-mass VLM binaries (or simply VLM binaries; see the Very Low Mass Binaries Archive maintained by Nick Siegler containing an up-to-date list of stellar and substellar binary systems with estimated total masses $M_1 + M_2 < 0.2 M_\odot$).

The vast majority of the equal-mass VLM binaries yet found have relatively small angular separations (of less than 1 arcsec) and can be only resolved with the *Hubble* Space Telescope or Adaptive Optics systems (e.g. Bouy et al. 2005; Siegler et al. 2005). If the SE 70 + S Ori 68 system in the σ Orionis cluster is not considered (without proper-motion confirmation; Caballero et al. 2006), there are only six known VLM binaries with $M_1 + M_2 < 0.2 M_\odot$ separated by more than 50 AU. Three are in very young star-forming regions (Ophiuchus, Chamaeleon I), which probably will not survive the tidal disruption field within the clusters, and three are field VLM binaries. The latter are DENIS-P J055146.0–443412 (DE0551–44AB; $r \approx 220$ AU; Billères et al. 2005), Koenigstuhl 1 AB (Kö 1AB; $r = 1800 \pm 170$ AU; Caballero 2007) and 2MASS J012655.49–502238.8 + 2MASS J012702.83–502221.1 (2M0126–50AB; $r = 5100 \pm 400$ AU; Artigau et al. 2007). Their mass ratios and total masses vary in the intervals $0.77 \lesssim q \lesssim 0.97$ and $0.17 M_\odot \lesssim M_1 + M_2 \lesssim 0.19 M_\odot$, respectively. There are other known VLM multiple systems in the field with separations larger than 1000 AU. However, their total masses are several times larger than those of the equal-mass VLM binaries and their mass ratios q significantly deviate from unity. For example, the mass ratio between vB 8 (M7.0V, $r \sim 1400$ AU) and GJ 644 A–BD + GJ 643 in the V1054 Oph quintuple system is $q \approx 0.065$, and its total mass is about $1.3 M_\odot$ (Kuiper 1934; Weis 1982; D’Antona 1986; Söderhjelm 1999; Mazeh et al. 2001).

2M0126–50AB and Kö 1AB, whose secondary has a mass at the substellar boundary, are by far the widest equal-mass VLM binaries yet found in the field and are part of a new differentiated binary class. Their separations are orders of magnitude larger than those of the VLM tight binaries. They represent a challenge for the widely accepted idea that lighter systems tend to have smaller separations (Sterzik & Durisen 2004) and for the “embryo-ejection” scenario of formation of substellar objects (Reipurth & Clarke 2001; Bate, Bonnell & Bromm 2003). Large hydrodynamical simulations can produce wide low-mass binary systems, albeit rarely. Bate & Bonnell (2005) showed an exotic situation in which two low-mass M dwarfs (about $0.18 M_{\odot}$ each) were almost simultaneously ejected with similar velocities from a small group of protostars. As the two objects moved away from the group, it turned out that they were weakly bound into a wide binary system. Their binding energy was, however, ~ 4.4 times larger than that of Kö 1AB and ~ 12 than that of 2M0126–50AB. Further discussion on how wide equal-mass VLM binaries represent a key diagnostic of star formation theories can be found in Billères et al. (2005), Phan-Bao et al. (2005), Burgasser et al. (2007), Caballero (2007), and Artigau et al. (2007). Caballero (2007) suggested that the wide separation between the components of Kö 1AB might be also due to perturbation resulting from encounters with more massive objects as they traveled in the Galaxy, and not only to the formation mechanism.

Both 2M0126–50AB and Kö 1AB are exceptional binaries, but it is not known yet *how* rare they are. In this work, I present the results of the Koenigstuhl survey of wide VLM dwarf binaries in the Southern Hemisphere and measure for the first time the frequency of equal-mass VLM systems. It complements the near-infrared proper motion search for companions to K5.0V–M7.0V stars at separations ~ 100 –1400 AU carried out by Hinz et al. (2002) and the Cerro Tololo Inter-American Observatory Parallax Investigation of nearby multiples, primarily M dwarfs, by Jao et al. (2003).

2. The Koenigstuhl survey

I have performed a proper-motion survey, called Koenigstuhl, using the the UKST and POSS–I plates and the SuperCOSMOS Science Archive (SSA; Hambly et al. 2001a). The survey is limited to declination $< +3^{\circ}$, where SSA data are only available. I have investigated 173 VLM field dwarfs with spectral types between M5.5V and L8.0V and brighter than $J \sim 14.5$ mag. Their names, coordinates, proper motions, and spectral types are provided in Table 3 (if tight binaries, only one spectral type is given). The bulk of them were taken from Cruz et al. (2003) and Phan-Bao & Bessel (2006). The SSA proper-motion measurements are accurate to $\sim 10 \text{ mas a}^{-1}$ at photographic B_J , $R \sim 19$ –18 mag and to $\sim 50 \text{ mas a}^{-1}$ at B_J ,

$R \sim 22$ – 21 mag (Hambly et al. 2001b), which are the expected magnitudes of the faintest investigated VLM dwarfs. Three nearby stars are however too bright in the SuperCOSMOS images (Proxima Centauri, BL Cet + UV Cet, and EZ Aqr, which saturate in the digitized photographic plates and whose proper motions are not tabulated by SuperCOSMOS). I have taken the values of their proper motions from Perryman et al. (1997) and Salim & Gould (2003). Besides, I have not identified in the SSA data L 143–23 (M5.5V; with a low galactic latitude), HD 16270 B (L1.0V; in the glare of the K3.0V primary), and several mid-L dwarfs fainter than $J \sim 13.0$ mag.

The survey procedure was similar to that in Caballero (2007). I downloaded the astrometric and photometric SSA data of all the sources in a 10-arcmin radius centered in each field dwarf and searched for stars or brown dwarfs with similar proper motions to those of the main targets. The threshold, $\Delta\overline{\mu}$, of the “similarity” was at about four times the error in the proper motion of the programme field dwarfs ($\Delta\overline{\mu} \approx 4\delta\mu$, where $\delta\mu = (\delta^2\mu_\alpha \cos \delta + \delta^2\mu_\delta)^{1/2}$). The error $\delta\mu$ increased for faint objects with late spectral types and large proper motions. Once a common-proper-motion candidate was selected, it was astrometrically followed up using multi-epoch digitized plates from POSS I Red, UKST Blue, Red, and Infrared, and data from 2MASS and DENIS catalogues (and the *Spitzer* Science Archive, if available). Time base-line was typically from first epochs 1950–1954 to last epochs 1999–2000, covering about half a century. Spurious SSA detections at only two blue optical bands without near-infrared counterparts were discarded from the study. The total survey area was 15.1 deg^2 . Fig. 1 illustrates the proper-motion diagrams of four representative VLM dwarfs under study.

3. Results

In the Koenigstuhl sample, there are 15 known tight binary and triple systems unresolved in the SSA images (neither in the 2MASS data). They are marked with “AB (C)” in Table 3. Besides, there are only five previously-known resolved common-proper-motion multiple systems: α Cen AB + Proxima Centauri, V1054 Oph ABCDE, G 124–62 A– BC ($r \sim 1500$ AU; BC: DENIS–P J144137.3–094559 AB; Seifahrt, Guenther & Neuhäuser 2005), GJ 1001 A– BC ($r \sim 180$ AU; Goldman et al. 1999), and 2M0126–50AB.

3.1. Koenigstuhl 1, 2, and 3

Three new common-proper motion systems have arisen from the Koenigstuhl survey. Their basic properties (ρ , θ , d , r , M_1 , M_2) are summarized in Table 1. The uncertainties

in the determination of the common proper motions of the two components in the three systems, measured with the value $\frac{\sigma_\rho}{\Delta t / \mu}$ (where σ_ρ is the standard deviation of the mean angular separation, Δt is the time baseline, and μ is the modulus of the mean proper motion) are at the level of only 1.1–3.3 %. False-color images centered on two of the new common-proper motion systems are shown in Figs. 2 and 3.

3.1.1. Koenigstuhl 1 AB (Kö 1AB)

Kö 1AB, formed by LEHPM 494 and DENIS-P J0021.0–4244, was presented in Caballero (2007). In this work, I provide a new imaging epoch obtained with the IRAC instrument onboard the *Spitzer* Space Telescope. I downloaded the images of the four channels, taken on J2003.970 (four years after the last epoch in Caballero 2007) and performed standard astrometry. The new measurement of the angular separation, of 77.74 ± 0.10 arcsec, perfectly agrees with what was expected. I compute more accurate average separation and position angle of Kö 1AB, given in Table 1. The expected semimajor axis of the parallax ellipse is ~ 0.04 arcsec.

3.1.2. Koenigstuhl 2 AB (Kö 2AB)

The second new common-proper-motion is formed by LP 655–23 and 2MASS J0430516–084901 (Kö 2AB). They maintain a constant angular separation of 19.7 ± 0.2 arcsec during six epochs from J1954.005 and J2000.005. The VLM field dwarf target was the secondary, an M8.0V at 22.9 ± 1.9 pc (Cruz et al. 2003). The primary, LP 655–23, was tabulated in the high proper-motion stars Luyten-Palomar and New Luyten Two Tenths catalogs (Luyten 1979). Improved astrometry, identical within the errorbars to the one presented here, was published by Salim & Gould (2003). None of them has been further investigated. Assuming that the binary is older than 1 Ga, the NextGen98 models of Baraffe et al. (1998) and the Dusty00 models of Chabrier et al. (2000) provide masses of 0.26 ± 0.04 and $0.086 \pm 0.004 M_\odot$ for the primary and the secondary, respectively ($q = 0.33 \pm 0.05$). The colors and the theoretical effective temperature from the models of LP 655–23 correspond to early-M spectral type. Using the distance estimate by Cruz et al. (2003), both M dwarfs are separated by 450 ± 40 AU. This value makes Kö 2AB to be the second widest system in the field with $M_1 + M_2 < 0.4 M_\odot$ after Kö 1AB and 2M0126–50AB, and together with the M4.5V+L6.0V binary LP 261–75 + 2MASS J09510549+3558021 ($\rho = 450 \pm 120$ AU; Reid & Walkowicz 2006)

3.1.3. *Koenigstuhl 3 A-BC (Kö 3A-BC)*

The third and last new common-proper motion system, Kö 3A- BC, is formed by the F8V star HD 221356 A and the M8.0V+L3.0V binary HD 221356 BC (BC: 2MASS J23310161-0406193AB). In the discovery paper of 2M2331-04 (as a single object), Gizis et al. (2000) reported that the derived photometric distance to the M8.0V was consistent with the Hipparcos distance to the nearby star HD 221356. However, the proper motion of the secondary tabulated by them, $(+401, -231)$ mas a⁻¹, clearly deviated from the Hipparcos proper motion of the F8V, $(+178.6 \pm 1.0, -192.8 \pm 0.8)$ mas a⁻¹. The M8.0V was afterwards found to be an 0.573-arcsec double by Gizis et al. (2003).

During the astrometric follow up, I have used six epochs from J1951.583 to J1999.882, and measured the mean separation between HD 221356 and 2M2331-04AB at $\rho = 451.8 \pm 0.4$ arcsec (the photo-centroid of the primary was computed using their spikes as a reference). The projected physical separation of $11\,900 \pm 300$ AU makes the triple the widest star system with an L-type component (it is 3.3 times wider than the η CrB ABC, the formerly widest such system, which is formed by an L8V secondary and a G1V+G3V spectroscopic-binary primary; Kirkpatrick et al. 2001).

The measurement of the common proper motion, with an uncertainty of only 9 mas a⁻¹, is very important because it helps to constraint the properties of the VLM binary HD 221356 BC/- 2M2331-04AB/ Kö BC. Using the Hipparcos trigonometric parallax of HD 221356 A, the age of $5.7^{+9.0}_{-0.2}$ Ga tabulated by Nordström et al. (2004), the combined 2MASS J magnitude of Kö 3BC (Cutri et al. 2003), their ρ and ΔJ given by Gizis et al. (2003), and the Dusty00 models I have determined new accurate theoretical masses for the M8.0V+L3.0V binary (given in Table 1). The L3.0V has an estimated mass larger than previously estimated. The errorbars in the masses only account for the uncertainties in the distance, age and J -band magnitudes, but not for the systematic errors of the theoretical models. The determination of the dynamical masses of Kö 3BC through astrometric and radial-velocity monitoring will help to estimate those systematic errors. The orbital period of Kö 3BC, $P \sim 146$ a ($a \sim 15.0$ AU; I assume a circular, face on, orbit, and adoption of the separation as the semimajor axis of the orbit), is quite similar to that predicted by Gizis et al. (2003). The orbital period of the binary surrounding the F8V is a bit larger than 1 Ma. Finally, the metallicity of the primary and, therefore, of the system is also known ($[M/H] = -0.23$; Karataş, Billir & Schuster 2005), which may help to further spectral classification of the L3.0V component (Kirkpatrick 2005).

3.2. Probable background non-companions

I have found 14 stars at angular separations less than 10 arcmin to the investigated dwarfs (12 000 AU at a typical heliocentric distance of 20 pc) with proper motions within the $4\Delta\mu$ threshold and that seem to be background stars with spectral types earlier than M5V. Their basic data are given in Table 2. BD–20 3682 is an early-F star located at 200 ± 70 pc to the Sun from *Hipparcos* parallax and at 7.0 arcmin to 2M1237–21, which in contrast is an M6 dwarf at only 32 ± 6 pc (Cruz et al. 2003). BD–20 3682 was classified as a low-metallicity subdwarf by Ryan & Norris (1991). HD 117332, the brightest background non-companion, is a G0-type star whose X-ray counterpart was detected by Schwöpe et al. (2000). It is located far beyond the 27.0 ± 2.2 pc estimated by Cruz et al. (2003) for 2M1330–04. Of the remaining 12 stars, six are fainter than the VLM target dwarfs, but have bluer optical-near infrared colors (e.g. $I - K_s \lesssim 1.6$ mag), on the contrary to what was expected if they formed a common-proper motion pair. Other three stars are brighter than the VLM targets, but the distances roughly estimated from their colors and magnitudes do not match those of the VLM dwarfs.

I have made astrometric follow up of the three remaining companion candidates, that are brighter than their respective VLT dwarfs: 2MASS J012704.7–501711, LP 679–39 and LP 798–19. On the one hand, LP 679–39 is a background G:-type star (SIMBAD) whose projected physical separation of 6.4 arcmin to 2M1413–04 varied 6 arcsec in a time base-line of 42 a and, therefore, they do not share a common proper motion. On the other hand, I failed to ascertain the common-proper motion status of LP 798–19 and 2M1339–17 ($\rho = 9.489\pm0.010$ arcmin, $\theta = 342.88\pm0.09$ deg) and of 2MASS J012704.7–5017112 and 2M0126–50AB ($\rho = 5.656\pm0.006$ arcmin, $\theta = 344.93\pm0.06$ deg). 2M1339–17 is an M7.5V located at 31 ± 3 pc (Cruz et al. 2003), while LP 798–19 seems to be an early M at 30–40 pc, based on their optical and near-infrared magnitudes. 2M0126–50AB is the wide equal-mass binary found by Artigau et al. (2007), with a photometric distance of $d \sim 62$ pc, while 2MASS J012704.7–5017112, with a red color $I - K_s \sim 2.2$ mag and about 2 mag brighter in J than 2M0126–50AB, is investigated here for the first time. I have measured marginal variations of $\Delta\rho \sim 1$ arcsec of the two systems during 43- and 20-year base-lines. Additional imaging epochs are needed to discard or confirm their common proper motions.

3.3. Miscellanea

As a by-product of the survey, I have measured for the first time the proper motions of 76 VLM field dwarfs (marked with “(1)” in Table 3). Accurate, homogeneous coordinates are also provided for the 173 dwarfs and 8 resolved proper-motion companions.

I have determined the mean angular separation between 2M0126–50A and B (Artigau et al. 2007) at 81.93 ± 0.18 arcsec, constant within the uncertainties during my time baseline of 18.0 a (2M0126–50B is not visible in the UKST B_J digitization).

Also, the double 2M0429–31AB (M7.5V+L1.0V – Cruz et al. 2003; Siegler et al. 2005) is at only 7.2 arcsec to the faint X-ray source 1RXS J042918.9–312401 (Voges et al. 2000), suggesting relationship.

4. The frequency of wide very low-mass binaries

Of the 173 investigated VLM dwarfs, 13 have large $\delta\mu$ -to- μ ratios (marked with “(3)” in Table 3), which prevented from searching common-proper motion companions surrounding them. Therefore, 160 dwarfs remain for statistical purposes. Taking into account the 15 unresolved systems, the five previously-known resolved systems, and the three new Koenigstuhl systems, then the frequency of multiplicity in the magnitude-limited sample of VLM dwarfs in the spectral-type interval M5.5V–L8.0V is $\gtrsim 14\%$. This value is a lower limit because most of the programme targets have not been yet investigated with high-spatial-resolution facilities. I refer to Close et al. (2003), Siegler et al. (2005), Burgasser et al. (2005), and references therein to find accurate frequencies of close multiples ($r < 30$ AU) at the 10–30 % level. These values must be compared to the upper limit of relatively wide companion frequency at 2–31 arcsec to M7–L8 dwarfs recently determined by Allen et al. (2007), of 2.3 %. In contrast to these works, the Koenigstuhl survey is the only one able to study the frequency of very wide multiples ($r > 100$ AU) up to 6000–30 000 AU (at heliocentric distances $d = 5$ –50 pc). In the aforementioned spectral-type interval, the minimum frequency of VLM dwarfs in wide multiple systems is as low as $5.0 \pm 1.8\%$ (8 of 160; Poissonian errors). The actual frequency could be larger because this survey is not sensitive to the detection of very faint companions.

There are only two wide binaries in my survey with mass ratio $q > 0.5$, Kö 1AB and 2M0126–50AB (the other known field wide equal-mass VLM binary, DE0551–44AB, although it is in the Southern Hemisphere, is too faint for the magnitude-limited Koenigstuhl survey). The frequency of wide equal-mass VLM binaries is, therefore, $1.2 \pm 0.9\%$. Despite the fact that it is not clear whether the origin of the wide separations between Kö 1A and B and 2M0126–50A and B resides on the formation mechanism or in the gravitational tidal disruption within the Galactic disk (or in both of them), my survey has confirmed the low frequency of wide equal-mass VLM binaries. Further theoretical studies of formation in collapsing molecular clouds and of the interaction of low binding-energy binaries with the gravitational field of the Galactic disk must account this low frequency.

To derive a more accurate frequency of wide equal-mass VLM binaries, the Koenigstuhl survey should be complemented in the future with new very wide photometric and astrometric searches in both Southern and Northern Hemispheres.

5. Summary

I have investigated 173 very low-mass stars and brown dwarfs during a proper-motion survey of resolved binary and multiple systems with very low-mass components, named Koenigstuhl. The studied field dwarfs have spectral types $> M5.0V$, magnitudes $J \lesssim 14.5$ mag, and declinations $\delta < +3$ deg. I looked for common-proper companions within a radius of 10 arcmin centered on the dwarfs using astrometric data from the SuperCOSMOS Science Archive. Of the investigated very low-mass dwarfs, 160 could actually be searched. I firstly provide the proper motions of 76 dwarfs.

I have identified five previously known wide multiples, confirmed the common-proper motion of two wide very low-mass binaries with mass ratio $q > 0.5$ (Koenigstuhl 1 AB and 2M0126–50AB), and measured for the first time the common-proper motion of two new wide systems containing very low-mass components, Koenigstuhl 2 AB and 3 A–BC. Koenigstuhl 2 AB is formed by the early-M, high proper-motion star LP 655–23 and the M8.0V dwarf 2M0430–08. Their low total mass ($M_1 + M_2 \approx 0.35 M_\odot$) and relatively large separation ($\rho = 450 \pm 40$ AU) and mass ratio ($q = 0.33 \pm 0.05$) make the system to be one of the lowest-mass, widest binaries yet found. The components of Koenigstuhl 3 A–BC are the F8V star HD 221356 and the M8.0V+L3.0V tight binary 2M2331–04AB. They are separated by ~ 7.5 arcmin ($\sim 12\,000$ AU at the *Hipparcos* distance of the primary), which makes Koenigstuhl 3 A–BC to be by far the widest system containing an L-type dwarf. The knowledge of the basic properties of the primary (distance, age, metallicity) and, therefore, of the very low-mass binary companion, will allow to test theoretical models and classification schemes of ultracool dwarfs with very late spectral types.

Finally, I have determined the minimum frequency of field wide multiples ($r > 100$ AU) with very low-mass components at $5.0 \pm 1.8\%$ and the frequency of field wide very low-mass components binaries with mass ratios $q > 0.5$ at $1.2 \pm 0.9\%$.

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L, and T dwarf compendium¹, the RECONS (Research Consortium on Nearby Stars) List of the Nearest 100 Stellar Systems², the Very Low Mass Binaries Archive³, the Extrasolar Planets Encyclopaedia⁴, the Two-Micron All Sky Survey, the Deep Near Infrared Survey of the Southern Sky, the USNO-B1 and NOMAD catalogues, the SuperCOSMOS and *Spitzer* Science Archives, and the SIMBAD database. Partial financial support was provided by the Spanish Ministerio de Ciencia y Tecnología project AYA2004-00253 of the Plan Nacional de Astronomía y Astrofísica.

REFERENCES

- Allen P. R., Koerner D. W., McElwain M. W., Cruz K. L. & Reid I. N. 2007, *AJ*, 133, 971
- Artigau É., Lafrenière D., Doyon R., Albert L., Nadeau D. & Robert J. 2007, *ApJ*, 659, L49
- Baraffe I., Chabrier G., Allard F., & Hauschildt P. H. 1998, *A&A*, 337, 403
- Bate M. R., Bonnell I. A. & Bromm V. 2003 *MNRAS*, 339, 577
- Bate M. R. & Bonnell I. A. 2005 *MNRAS*, 356, 1201
- Billères M., Delfosse X., Beuzit J.-L., Forveille T., Marchal L. & Martín E. L. 2005, *A&A*, 440, L55
- Bouy H., Martín E., Brandner W., Bouvier J. 2005, *AN*, 326, 969
- Burgasser A. J., Kirkpatrick J. D. & Lowrance P. J. 2005, *AJ*, 129, 2849
- Burgasser A. J., Reid I. N., Siegler N., Close L., Allen P., Lowrance P. & Gizis J. 2007, *Protostars and Planets V*, Bo Reipurth, D. Jewitt, and K. Keil (eds.), University of Arizona Press, Tucson, 951 pp., 2007., p.427–441
- Caballero J. A., Martín E. L., Dobbie P. D. & Barrado y Navascués D. 2006, *A&A*, 460, 635
- Caballero J. A. 2007, *A&A*, 462, L61

¹<http://DwarfArchives.org>

²<http://www.chara.gsu.edu/RECONS/>

³http://paperclip.as.arizona.edu/~nsiegler/VLM_binaries

⁴<http://exoplanet.eu/>

- Chabrier G., Baraffe I., Allard F. & Hauschildt P. 2000, *ApJ*, 542, 464
- Close L. M., Siegler N., Freed M. & Biller B. 2003, *ApJ*, 587, 407
- Cruz K. L., Reid I. N., Liebert J., Kirkpatrick J. D. & Lowrance P. J. 2003, *AJ*, 126, 2421
- Cutri R. M., Skrutskie M. F., van Dyk S. et al. 2003, The IRSA 2MASS All-Sky Point Source Catalog, NASA/IPAC Infrared Science Archive
- D’Antona F. 1986, *MmSAI*, 57, 317
- Gizis J. E., Monet D. G., Reid I. N., Kirkpatrick J. D., Liebert J. & Williams R. J. 2000, *AJ*, 120, 1085
- Gizis J. E., Reid I. N., Knapp G. R., Liebert J., Kirkpatrick J. D., Koerner D. W., Burgasser A. J. 2003, *AJ*, 125, 3302
- Goldman B., Delfosse X., Forveille T., Afonso C., Alard C., Albert J. N., Andersen J., Ansari R., Aubourg É. et al. (EROS Collaboration) 1999, *A&A*, 351, L5
- Hambly N. C., MacGillivray H. T., Read M. A. et al. 2001a, *MNRAS*, 326, 1279
- Hambly N. C., Davenhall A. C., Irwin M. J. & MacGillivray H. T. 2001b, *MNRAS*, 326, 1315
- Heintz W. D. 1987, *ApJS*, 65, 161
- Hinz J. L., McCarthy D. W. Jr., Simons D. A., Henry T. J., Kirkpatrick J. D. & McGuire P. C. 2002, *AJ*, 123, 2027
- Jao W.-C., Henry T. J., Subasavage J. P., Bean J. L., Costa E., Ianna P. A. & Méndez R. A. 2003, *AJ*, 125, 332
- Karataş Y., Billir S. & Schuster W. J. 2005, *MNRAS*, 360, 1345
- Kirkpatrick J. D., Dahn C. C., Monet D. G., Reid I. N., Gizis J. E., Liebert J. & Burgasser A. J. 2001, *AJ*, 121, 3235
- Kirkpatrick J. D. 2005, *ARA&A*, 43, 195
- Kuiper G. P. 1934, *PASP*, 46, 235
- Luyten W. J. 1979, LHS catalogue. A catalogue of stars with proper motions exceeding 0."5 annually, Minneapolis: University of Minnesota, 1979, 2nd ed.

- Mazeh T., Latham D. W., Goldberg E., Torres G., Stefanik R. P., Henry T. J., Zucker S., Gnat O. & Ofek E. O. 2001, MNRAS, 325, 343
- McCaughrean M. J., Close L. M., Scholz R.-D., Lenzen R., Biller B., Brandner W., Hartung M. & Lodieu N. 2004, A&A, 413, 1029
- Nordström B., Mayor M., Andersen J., Holmberg J., Pont F., Jørgensen B. R., Olsen E. H., Udry S. & Mowlavi N. 2004, A&A, 418, 989
- Perryman M. A. C., Lindegren L., Kovalevsky J. et al. 1997, A&A, 323, L49
- Phan-Bao N., Martín E. L., Reylé C., Forveille T. & Lim J. 2005, A&A, 439, L19
- Phan-Bao N. & Bessell M. S. 2006, A&A, 446, 515
- Reid I. N. & Walkowicz L. M. 2006, PASP, 118, 671
- Reipurth Bo & Clarke C. 2001, AJ, 122, 432
- Ryan S. G. & Norris J. E. 1991, AJ, 101, 1835
- Salim S. & Gould A. 2003, ApJ, 582, 1011
- Scholz R.-D., McCaughrean M. J., Lodieu N. & Kuhlbrodt B. 2003, A&A, 398, L29
- Schwöpe A., Hasinger G., Lehmann I., Schwarz R., Brunner H., Neizvestny S., Ugryumov A., Balega Yu., Trümper J. & Voges W. 2000, AN, 321, 1
- Seifahrt A., Guenther E. & Neuhäuser R. 2005, A&A, 440, 967
- Siegler N., Close L. M., Cruz K. L., Martín E. L., Reid I. N. 2005, ApJ, 621, 1023
- Söderhjelm S. 1999, A&A, 341, 121
- Sterzik M. F. & Durisen R. H. 2004, RMxAC, 21, 58
- Voges W., Aschenbach B., Boller Th. et al. 2000, IAU Circ., 7432, 3 (2000). Edited by D. W. E. Green
- Weis E. W. 1982, AJ, 87, 152
- Wertheimer J. G. & Laughlin G. 2006, AJ, 132, 1995

Table 1. New common-proper motion systems identified in the Koenigstuhl survey.

Name	Primary	Secondary	ρ (arcmin)	θ (deg)	d^a (pc)	r (AU)	M_1^b (M_\odot)	M_2^b (M_\odot)
Kö 1AB	LEHPM 494	DE0021–42	1.2956 ± 0.0012	316.97 ± 0.08	23 ± 2	1800 ± 170	0.103 ± 0.006	0.079 ± 0.004
Kö 2AB	LP 655–23	2M0430–08	0.328 ± 0.004	339.9 ± 0.4	22.9 ± 1.9	450 ± 40	0.26 ± 0.04	0.086 ± 0.004
Kö 3A–BC	HD 221356	2M2331–04AB	7.530 ± 0.007	261.77 ± 0.06	26.2 ± 0.6	11900 ± 300	$1.02^{+0.07}_{-0.06}$	0.088 ± 0.002 (B) 0.072 ± 0.001 (C)

^aErrors in distance estimates have been adopted from the literature.

^bMass errors are from theoretical fits to available data, and are not realistic.

Table 2. Probable non-common proper motion companions to the investigated dwarfs.

Name	VLM dwarf	$\mu_\alpha \cos \delta$ (mas a ⁻¹)	μ_δ (mas a ⁻¹)	B (mag)	R (mag)	I (mag)	J (mag)	K_s (mag)
G 271–43 ^a	DE0120–07	+20±30	–180±30	~15.7	~14.0	13.74±0.03	12.87±0.02	12.19±0.03
2MASS J012704.7–501711	2M0126–50AB	+135±12	–12±9	~17.8	~15.6	~14.0	12.57±0.02	11.79±0.02
2MASS J033411.0–212412	2M0334–21	+139±12	–12±11	~21.1	~18.7	~16.6	15.25±0.04	14.41±0.09
2MASS J095210.2–193029	DE0952–19	–71±7	–96±7	~18.7	~16.4	~15.0	14.11±0.04	13.39±0.04
BD–20 3682 ^{a,b}	2M1237–21	–177.1±1.8	–43.0±1.3	11.09±0.07	~9.9	10.14±0.02	9.72±0.03	9.39±0.02
2MASS J123723.7–210939	2M1237–21	–201±9	–47±7	~20.2	~18.0	16.21±0.06	14.74±0.04	13.90±0.05
2MASS J123758.2–211521	2M1237–21	–259±12	–37±10	~20.1	~19.5	17.06±0.13	15.77±0.05	14.90±0.11
HD 117332 ^{a,b}	2M1330–04	–34±3	+4±2	10.28±0.04	~9.0	~8.9	8.10±0.04	7.65±0.02
2MASS J132947.9–050125	2M1330–04	–58±7	–3±6	~17.1	~15.2	~14.4	12.69±0.03	12.52±0.03
LP 798–19 ^a	2M1339–17	–224±9	–54±11	~14.8	~12.8	11.34±0.03	10.00±0.02	9.21±0.02
2MASS J135751.0–143458	2M1357–14	–58±7	–118±6	~18.8	~17.4	~16.8	15.99±0.08	15.34±0.19
LP 679–39 ^a	2M1413–04	–149±9	–132±7	~13.4	~11.6	12.01±0.02	11.13±0.03	10.37±0.02
2MASS J220659.4–204323	DE2206–20AB	+34±14	–30±20	~13.7	~11.8	11.96±0.02	11.18±0.02	10.55±0.02
2MASS J230702.5–050234	2M2306–05	–55±8	–93±8	~20.7	~17.8	~16.8	15.41±0.06	14.78±0.10

^aJ2000 coordinates. G 271–43: 01 21 10.0 –07 39 21; BD–20 3682: 12 36 59.3 –21 20 38; HD 117332: 13 29 43.2 –04 54 22; LP 798–19: 13 39 38.2 –18 04 09; LP 679–39: 14 14 21.8 –04 54 16.

^b B magnitudes and proper motions from the Hipparcos catalogue.

Table 3. Investigated very low-mass dwarfs and proper-motion companions.

Name	Alternative name	α (J2000)	δ (J2000)	$\mu_\alpha \cos \delta$ (mas a ⁻¹)	μ_δ (mas a ⁻¹)	Sp. type	Remarks (^a)
LP 584-4		00 02 06.2	+01 15 36	+480±20	+30±20	M6.5V	
GJ 1001	A	00 04 36.4	-40 44 02	+770±60	-1600±40	M3.5V	(2)
	BC	00 04 34.8	-40 44 06	+710±90	-1580±80	L4.5V+...	(2)
GJ 1002		00 06 43.3	-07 32 15	-800±60	-1920±70	M5.5V	(2)
LP 825-35	LEHPM 485	00 20 23.2	-23 46 05	+321±11	-73±10	M6.0V	
Koenigstuhl 1	A	LEHPM 494	00 21 10.4	+268±10	-21±8	M6.0:V	
	B	DE0021-42	00 21 05.7	+270±11	+4±10	M9.5V	
DY Psc	BRI B0021-0214	00 24 24.6	-01 58 20	-80±7	+137±7	M9.5V	
GJ 2005	ABC	LP 881-64	00 24 44.2	-27 08 24	-80±50	+610±70	M5.5V+...
DENIS-P J004135.3-562112		00 41 35.4	-56 21 13	+108±10	-63±8	M7.5V	
2MASS J00492677-0635467		00 49 27.9	-06 35 40	-111±8	-460±30	M8.5V	
RG 0050-2722		00 52 54.7	-27 06 00	+229±17	-332±16	M8.0V	
LP 938-71	LHS 132	01 02 51.0	-37 37 44	+1480±30	+200±30	M8.0:V	
DENIS J010311.9-535143		01 03 12.0	-53 51 43	-89±7	-204±5	M5.5V	
SSSPM J0109-5101		01 09 01.5	-51 00 50	+207±12	+87±11	M8.5V	
LP 647-13	NLTT 3868	01 09 51.2	-03 43 26	+380±50	+20±50	M9.0V	
DENIS-P J012049.1-074103		01 20 49.1	-07 41 03	+4±9	-153±9	M8.0V	
LEHPM 1505	SSSPM J0124-4240	01 24 59.1	-42 40 07	-141±9	-227±8	M7.0V	
2MASS J01265549-5022388	A	2M0126-50A	01 26 55.5	-50 22 39	+136±15	-47±14	M6.5V
	B	2M0126-50B	01 27 02.8	-50 23 21	+180±170	+160±160	M8.0V
BL Cet + UV Cet	GJ 65 AB	01 39 01.5	-17 57 02	+3295±5	+563±5	M5.5Ve+...	(4)
LEHPM 1781		01 41 14.8	-24 17 31	-145±13	-307±12	M7.5V	
DENIS J014431.8-460432		01 44 31.9	-46 04 32	+112±9	-47±8	M5.5V	
DENIS-P J014543.4-372959		01 45 43.5	-37 29 59	+175±12	-66±11	M7.5V	
2MASS J01483864-3024396		01 48 38.6	-30 24 40	-88±11	+44±10	M7.5V	(1)
LP 649-72	LHS 1363	02 14 12.5	-03 57 43	+490±50	-130±60	M6.5V	
LP 649-93	PB 9141	02 18 57.9	-06 17 50	+374±19	-91±18	M8.0V	(2)
2MASS J02192807-1938416		02 19 28.0	-19 38 41	+221±18	-132±17	L0.0V	(1)
LP 771-21	BR B0246-1703	02 48 41.0	-16 51 22	+22±15	-299±14	M8.0V	
LP 651-17	LHS 1450	02 50 02.4	-08 08 42	+590±20	+110±20	M5.5V	
2MASS J02511490-0352459		02 51 14.9	-03 52 46	+1000±200	-1800±200	L3.0V	
DENIS-P J025344.4-795913		02 53 44.5	-79 59 13	+71±9	+103±9	M5.5V	
DENIS-P J0255.0-4700		02 55 03.6	-47 00 51	+1060±50	-630±50	L8.0V	
LEHPM 3070		03 06 11.6	-36 47 53	+0±180	-570±170	M8.5V	
DENIS-P J031225.1+002158		03 12 25.1	+00 21 58	+178±18	-40±17	M5.5V	
2MASS J03144011-0450316		03 14 40.1	-04 50 32	-86±7	-101±7	M7.5V	(1)
2MASS J03202839-0446358		03 20 28.4	-04 46 36	-190±60	-560±60	M8.0:V	
DENIS J032058.8-552015		03 20 58.9	-55 20 16	+297±8	+264±8	M5.5V	
DENIS-P J032426.8-772705		03 24 26.9	-77 27 05	+265±19	+190±19	M6.0V	
LP 888-18	NLTT 11163	03 31 30.2	-30 42 38	+41±9	-402±9	M7.5V	
2MASS J03341065-2130343		03 34 10.7	-21 30 34	+140±7	-4±7	M6.0V	(1)
GJ 1061	LP 995-46	03 35 59.7	-44 30 45	+730±60	-330±20	M5.5V	
LP 944-20		03 39 35.2	-35 25 44	+290±12	+280±12	M9.0V	(2)
LP 593-68	GJ 3252	03 51 00.0	-00 52 45	+1±12	-474±12	M7.5V	
2MASS J03521086+0210479		03 52 10.9	+02 10 48	+260±30	+370±30	L1.0V	

Table 3—Continued

Name	Alternative name	α (J2000)	δ (J2000)	$\mu_\alpha \cos \delta$ (mas a ⁻¹)	μ_δ (mas a ⁻¹)	Sp. type	Remarks (^a)
2MASS J03542008-1437388		03 54 20.1	-14 37 39	-125±5	+58±5	M6.5V	(1)
2MASS J03550477-1032415		03 55 04.8	-10 32 42	+71±7	-35±7	M8.5V	(1)
LP 714-37	ABC	04 10 48.1	-12 51 42	-168±15	-395±22	M6.0V+...	(2)
LP 890-2	NLTT 12812	04 13 39.8	-27 04 29	+270±7	-31±7	M6.0V	
2MASS J04173745-0800007		04 17 37.5	-08 00 01	+670±70	-90±70	M7.5V	(1)
2MASS J0422205-360608		04 22 20.6	-36 06 08	+207±8	-40±8	M6.5V	(1)
2MASS J04235322-0006587		04 23 53.2	-00 06 59	-130±160	-240±150	M8.5V	(1), (3)
2MASS J04285096-2253227		04 28 51.0	-22 53 23	+97±13	+156±13	L0.5V	
2MASS J04291842-3123568	AB	04 29 18.4	-31 23 57	+97±5	+71±6	M7.5V+...	(1)
LP 655-23	A	NLTT 13422	04 30 52.0	-08 49 19	+7±15	M:V	
	B	2M0430-08	04 30 51.6	-08 49 01	-4±11	M8.0V	(1)
LP 775-31	NLTT 13580	04 35 16.1	-16 06 58	+162±18	+313±20	M7.5V	
2MASS J04351455-1414468		04 35 14.6	-14 14 47	+0±10	+11±10	young	(1), (3)
DENIS J043627.8-411446		04 36 27.9	-41 14 46	+71±10	+20±10	M7.5V	
2MASS J04393407-3235516		04 39 34.1	-32 35 52	-97±5	-1±6	M6.5V	(1)
LP 655-48		04 40 23.2	-05 30 08	+335±7	+115±8	M7.0V	
2MASS J04451119-0602526		04 45 11.2	-06 02 53	+49±6	-21±6	M7.0V	(1)
2MASS J04453237-3642258		04 45 32.4	-36 42 26	+520±70	+10±70	M9.0:V	(1)
2MASS J04455387-3048204		04 45 53.9	-30 48 20	+167±12	-424±12	L2.0V	(1)
2MASS J04510093-3402150		04 51 00.9	-34 02 15	+94±17	+114±16	L0.5V	(1)
2MASS J05023867-3227500		05 02 38.7	-32 27 50	+53±7	-175±7	M6.5V	(1)
2MASS J05084947-1647167		05 08 49.5	-16 47 17	-220±20	-360±20	M8.0V	(1)
DENIS-P J051737.7-334903		05 17 37.7	-33 49 03	+460±12	-319±12	M8.0V	(2)
2MASS J05233822-1403022		05 23 38.2	-14 03 02	+105±7	+158±7	L2.5V	(1)
2MASS J05284435-3252228		05 28 44.4	-32 52 23	-10±20	+50±20	M8.5V	(1), (3)
2MASS J06003375-3314268		06 00 33.8	-33 14 27	-15±10	+119±11	M7.5V	(1)
2MASS J06080232-2944590		06 08 02.3	-29 44 59	+30±20	+100±20	M8.5V	(1)
2MASS J06085283-2753583		06 08 52.8	-27 53 58	+30±30	-30±30	young	(1), (3)
2MASS J06441439-2841417		06 44 14.4	-28 41 42	+155±11	-36±11	M8.0V	(1)
2MASS J06572547-4019134		06 57 25.5	-40 19 14	-220±30	+26±11	M7.5V	(1), (2)
2MASS J07193188-5051410		07 19 31.9	-50 51 41	+140±30	-10±30	L0.0V	(1)
SSSPM J0829-1309		08 28 34.2	-13 09 20	-490±40	+10±40	L2.0V	
2MASS J08293244-0238543		08 29 32.4	-02 38 54	+4±6	-3±6	M8V.0	(1), (3)
2MASS J08354256-0819237		08 35 42.6	-08 19 24	-730±180	+310±170	L5.0V	(1)
2MASS J08472872-1532372		08 47 28.7	-15 32 37	-130±160	-20±160	L2.0V	(1), (3)
2MASS J08500174-1924184		08 50 01.8	-19 24 18	-144±17	+49±17	M8.0V	(1)
LP 666-9	GJ 3517	08 53 36.2	-03 29 32	-156±9	-139±9	M9.0V	
2MASS J0902146-064209		09 02 14.6	-06 42 10	+14±10	-39±9	M7.0V	(1)
2MASS J09033514-0637336		09 03 35.1	-06 37 34	-73±7	+13±6	M7.0V	(1)
DENIS-P J0909.9-0658	AB	09 09 57.5	-06 58 19	-280±190	+110±180	L0.0V	(1)
2MASS J09130443-0733042		09 13 04.4	-07 33 04	-50±50	-200±50	M9.0V	(1)
SIPS J0921-2104		09 21 14.1	-21 04 45	+100±60	-900±60	L2.0V	
2MASS J09263320-0151026		09 26 33.2	-01 51 03	-137±5	-31±5	M6.0V	(1)
LP 728-52	NLTT 22091	09 34 29.2	-13 52 43	-240±15	-143±13	M7.0:V	
DENIS J095221.9-192432		09 52 21.9	-19 24 32	-68±5	-107±5	M7.0V	

Table 3—Continued

Name	Alternative name	α (J2000)	δ (J2000)	$\mu_\alpha \cos \delta$ (mas a ⁻¹)	μ_δ (mas a ⁻¹)	Sp. type	Remarks (^a)
LP 609–24	LHS 5165	10 03 19.2	–01 05 08	–250±11	+32±9	M7.0V	
LP 789–23	NLTT 23415	10 06 32.0	–16 53 27	–280±20	+194±17	M7.5V	
2MASS J10184314–1624273		10 18 43.2	–16 24 27	+31±9	–22±8	M7.5V	(1)
DENIS–P J102132.3–204407		10 21 32.3	–20 44 07	–339±12	–50±12	M8.0V	(1)
LP 610–5	NLTT 24132	10 21 51.3	–03 23 10	+210±14	–151±10	M6.5V	
SDSS J104524.00–014957.6		10 45 24.0	–01 49 58	–520±40	–30±30	L1.0V	(1)
LP 731–58	GJ 3622	10 48 12.6	–11 20 08	+570±50	–1500±60	M6.5V	
DENIS–P J104814.7–395606		10 48 14.6	–39 56 06	–1470±100	–700±80	M8.5V	
SDSS J104842.81+011158.2		10 48 42.8	–01 11 58	–440±40	–240±30	L1.0V	(1)
DENIS–P J1058.7–1548		10 58 47.9	–15 48 17	–60±160	+210±150	L3.0V	
2MASS J11043351–0510439		11 04 33.5	–05 10 44	–101±8	–48±6	M6.0V	(1)
LP 731–47	BR B1104–1227	11 06 56.9	–12 44 02	–320±15	–14±13	M6.0V	
LP 732–20	LHS 2397	11 20 26.4	–14 40 02	–367±16	–377±14	M8.5V	
2MASS J11304761–2210335		11 30 47.6	–22 10 34	–146±16	–245±15	M8.0V	(1)
LP 673–63		11 36 41.0	–07 55 12	–190±20	+192±16	M6.0V	
DENIS J114144.0–223215		11 41 44.0	–22 32 15	–190±20	+430±20	M8.0V	
2MASS J11553952–3727350		11 55 39.5	–37 27 35	+13±15	–778±13	L2.0V	(2)
2MASSI J1158027–254536		11 58 02.7	–25 45 37	–80±14	–167±12	M9.0V	(1)
LP 908–5	NLTT 29333	12 01 42.1	–27 37 46	–229±12	+19±11	M5.5V	
2MASS J12023666–0604054		12 02 25.6	–06 04 05	+400±300	+300±200	M8.0V	(1), (3)
2MASS J12022564–0629026		12 02 36.7	–06 29 03	+200±300	–100±200	M9.0V	(1), (3)
LP 734–87	NLTT 30173	12 16 10.1	–11 26 10	+40±20	–240±16	M5.5V	
2MASS J12185957–0550282		12 18 59.6	–05 50 28	–330±70	+10±60	M8.5V	(1)
LP 908–68	LHS 325 a	12 23 56.3	–27 57 47	–1600±800	+800±800	M6.0V	
BRI B1222–1221		12 24 52.2	–12 38 35	–270±30	–220±20	M9.0V	
LP 909–55		12 36 15.3	–31 06 46	+161±7	–78±8	M5.5V	
2MASS J12372705–2117481		12 37 27.0	–21 17 48	–222±9	–42±7	M6.0V	(1)
2MASS J12473570–1219518		12 47 35.7	–12 19 52	–30±30	–260±20	M8.5V	(1)
Kelu 1	AB	13 05 40.2	–25 41 06	–310±12	–12±10	L2.0V+...	
CE 303		13 09 21.8	–23 30 35	+17±9	–372±8	M8.0V	
2MASS J13300232–0453202		13 30 02.3	–04 53 20	–79±9	–7±9	M8.0V	(1)
2MASS J13322442–0441126		13 32 24.4	–04 41 13	+59±19	–10±16	M7.5V	(1)
2MASS J13392651–1755053		13 39 26.5	–17 55 05	–190±20	–70±20	M7.5V	(1)
2MASS J13401152–1451591		13 40 11.5	–14 51 59	–101±17	–190±12	M6.5V	(1)
LP 911–56	CE 359	13 46 46.1	–31 49 26	–332±18	+154±17	M6.0V	(2)
DENIS–P J135714.9–143852		13 57 15.0	–14 38 53	–38±10	–106±9	M7.5V	
DENIS–P J141121.2–211950		14 11 21.3	–21 19 50	–58±9	–102±8	M9.0V	(1)
2MASS J14135981–0457483		14 13 59.8	–04 57 05	–190±50	–60±40	M8.0V	(1)
2MASS J14211873–1618201		14 21 18.7	–16 18 20	–230±20	–70±20	M7.5V	(1)
2MASS J14241870–3514325		14 24 18.7	–35 14 32	–2±7	–79±6	M6.5V	(1)
Proxima Centauri	α Cen C	14 26 19.0	–62 28 04	–3775±2	+769.3±1.3	M5.5V	(4)
G 124–62	A	14 41 35.8	–09 46 39	–208±9	–26±9	M4.5Ve	
	BC DE1441–27AB	14 41 37.2	–09 45 59	–190±80	+60±80	L1.0V+...	
DENIS J145601.3–274736		14 56 01.4	–27 47 37	–180±18	–204±16	M9.0V	
LP 914–54	GJ 3877	14 56 38.3	–28 09 47	–470±40	–900±60	M7.0V	

Table 3—Continued

Name	Alternative name		α (J2000)	δ (J2000)	$\mu_{\alpha} \cos \delta$ (mas a ⁻¹)	μ_{δ} (mas a ⁻¹)	Sp. type	Remarks (^a)
TVLM 868-54745			15 00 34.3	-00 59 45	+82±6	-6±6	M8.0:V	(1)
2MASS J15072779-2000431			15 07 27.8	-20 00 43	+109±9	-78±9	M7.5V	(1)
DENIS-P J151233.3-103241			15 12 33.3	-10 32 41	-40±20	-37±19	M8.5V	(1), (3)
2MASS J15551573-0956055			15 55 15.7	-09 56 06	-400±1200	-1900±1100	L1.0V	(3)
LSR J1610-0040			16 10 29.0	-00 40 53	-680±90	-1250±90	sdM/L:	
LP 624-54			16 14 25.2	-02 51 01	+6±14	+350±14	M6.0V	
2MASS J16452211-1319516			16 45 22.1	-13 19 52	-360±40	-820±40	L1.5V	(1)
LP 626-2			16 45 28.2	-01 12 29	-8±12	-226±13	M5.5V	
V1054 Oph	A-BE	GJ 664AB	16 55 28.8	-08 20 10	-900±50	-910±50	M3.0Ve+...	(2)
	C	GJ 663	16 55 25.3	-08 19 21	-830±30	-920±30	M4.0V+...	
	D	vB 8	16 55 35.3	-08 23 40	-790±20	-900±20	M7.0V	(2)
SCR J1845-6357	AB		18 45 05.4	-63 57 48	+2440±100	+700±120	M8.5V+...	
2DENIS-P J200213.4-542555			20 02 13.4	-54 25 56	+49±7	-367±8	M6.0V	(2)
2MASSI J2004536-141622			20 04 53.7	-14 16 23	+534±18	+56±17	M7.5V	(1)
2MASS J20140359-2016217			20 14 03.6	-20 16 22	+25±11	-124±12	M7.5V	(1)
2MASS J20151945-1601334			20 15 19.4	-16 01 34	-34±5	-101±5	M5.5V	(1)
2MASS J20192695-2502441			20 19 27.0	-25 02 44	-130±20	-90±20	M8.0V	(1)
2MASS J20335733-0429413			20 33 57.3	-04 29 41	+33±13	-257±13	M6.5V	(1)
2MASS J20370715-1137569	AB		20 37 07.2	-11 37 57	-30±30	-390±30	M8.0V+...	(1)
2MASS J20391314-1126531			20 39 13.1	-11 26 53	+64±11	-105±11	M8.0V	(1)
LP 695-351			20 41 41.0	-03 33 53	+166±5	-67±5	M6.0V	
2MASS J20473176-0808201			20 47 31.8	-08 08 20	+100±300	-200±300	M7.0V	(1), (3)
2MASS J20491972-1944324			20 49 19.7	-19 44 32	+179±9	-279±9	M7.5V	(1)
DENIS-P J205754.1-025229			20 57 54.1	-02 52 30	+20±30	-90±30	L1.5V	(1)
2MASS J21041491-1037369			21 04 14.9	-10 37 37	+550±170	-180±170	L3.0V	(1)
2MASS J21130293-1009412	AB		21 13 02.9	-10 09 41	-24±6	-122±7	M6.0V+...	(1)
2MASS J21254581-0018340			21 25 45.8	-00 18 34	+16±6	+22±7	M6.5V	(1), (3)
LP 698-2		NLTT 51488	21 32 29.8	-05 11 58	+126±11	-352±12	M6.0V	
LP 759-17			22 02 11.3	-11 09 46	+133±11	-192±11	M6.5V	
LP 759-25		NLTT 52882	22 05 35.8	-11 04 29	-173±8	-104±8	M5.5V	
DENIS J220622.7-204706	AB		22 06 22.8	-20 47 06	+30±9	-41±10	M8.0V+...	
2MASSI J2214506-131959			22 14 50.7	-13 19 59	+255±15	-263±15	M7.5V	(1)
2MASS J22263689-0239502			22 26 36.9	-02 39 50	+210±19	-81±19	M6.5V	(1)
EZ Aqr	ABC		22 38 33.6	-15 17 59	+2214±5	+2295±5	M5.5VST	(4)
LP 700-66		NLTT 54525	22 40 38.6	-02 50 56	+197±13	-241±13	M6.5V	
2MASSI J2252014-181558			22 52 01.5	-18 16 00	+81±15	-382±16	M8.5V	(1)
DENIS-P J225451.8-284025			22 54 51.9	-28 40 25	-50±50	+60±50	L0.5V	(1), (3)
2MASS J23062928-0502285			23 06 29.3	-05 02 28	-76±7	-95±7	M7.5V	(2)
LP 702-58		NLTT 56373	23 17 20.7	-02 32 32	+213±15	-92±17	M6.5V	
HD 221356		BD-04 5896	23 31 31.5	-04 05 14	+178.6±1.0	-192.8±0.8	F8.0V	(4)
	AB	2M2331-04AB	23 31 01.6	-04 06 19	+220±20	-190±20	M8.0V+...	
LP 732-20			23 37 14.9	-08 38 08	+248±13	+19±13	M7.0V	
LP 763-3		NLTT 57439	23 37 38.3	-12 50 28	+218±13	-317±12	M6.0V	
LEHPM 6334			23 51 50.4	-25 37 37	+376±18	+158±18	M9.0V	(2)
DENIS-P J235359.4-083331			23 53 59.5	-08 33 31	-580±200	-20±200	M8.5V	

Table 3—Continued

Name	Alternative name	α (J2000)	δ (J2000)	$\mu_\alpha \cos \delta$ (mas a ⁻¹)	μ_δ (mas a ⁻¹)	Sp. type	Remarks (^a)
LEHPM 6494	SSSPM J2356–3426	23 56 10.8	–34 26 04	+90±13	–306±13	M9.0V	

^aRemarks – (1): first proper motion measurement; (2): double detection in SSA; (3): high $\delta\mu/\mu$ ratio; (4): proper motion from the literature.

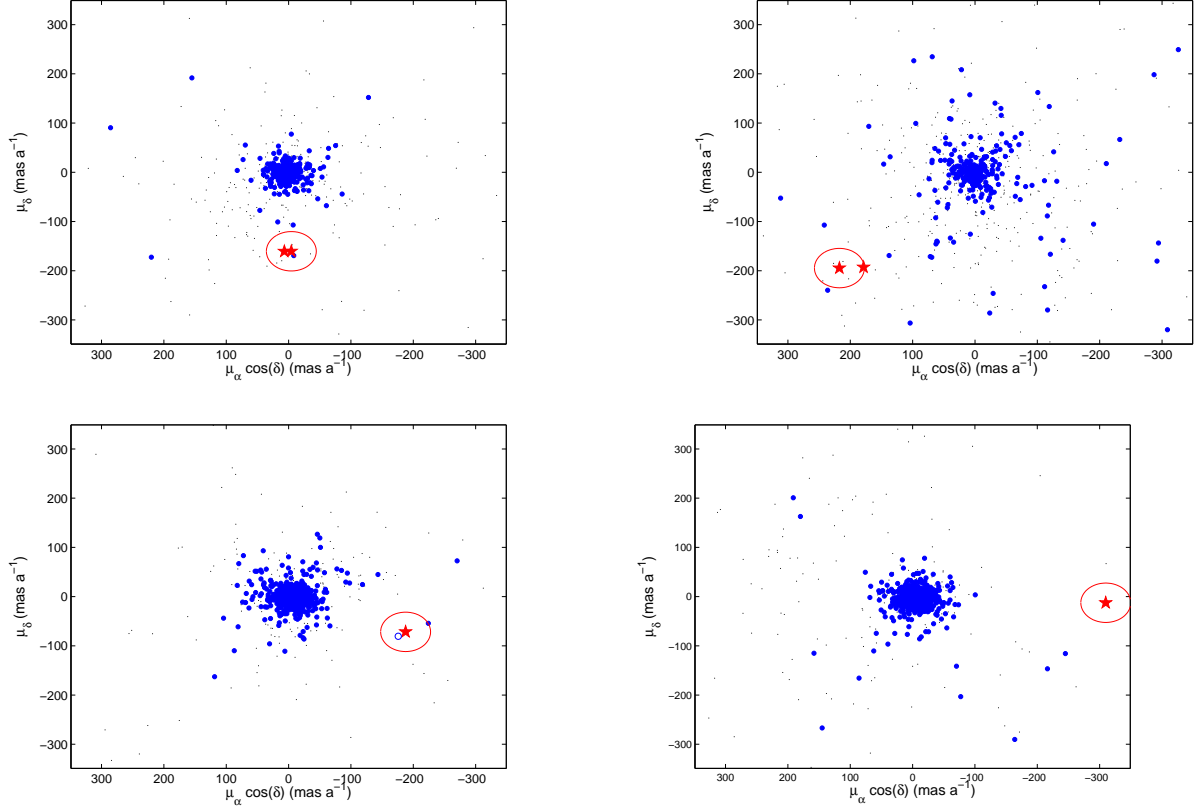


Fig. 1.— Proper-motion (μ_δ vs. $\mu_\alpha \cos \delta$) diagrams of four representative VLM dwarfs under study. Filled stars: VLM dwarfs and their proper-motion companions. Small filled circles: Background sources with detections in at least three SuperCOSMOS passbands. Tiny dots: All the detections, including spurious. Big open ellipses: 40 mas a^{-1} -radius circles centered on the VLM dwarfs. The scales are identical in the four diagrams. *Top left*: Kö 2AB (LP 655–23 and 2M0430–08; the small filled circle close to Kö 2AB is an artefact in the glare of the nearby star BD–02 912); *top right*: Kö 3A–BC (HD 221356 and 2M2331–04AB); *bottom left*: 2M1339–17 and the probable non-common proper motion companion LP 679–39, marked with a small open circle; *bottom right*: Kelu 1 AB. The proper-motion diagram of Kö 1AB is in Caballero (2007).

Fig. 2.— False-color composite images centered on the system LP 655–23 + 2M0430–08 (Koenigstuhl 2 AB). Red, green and blue are for photographic I_N (UKST), R (POSS–I) and B_J (UKST), taken at epochs separated by 46.0 years. North is up, east is left. *Left window:* 10×10 arcmin² field of view. *Right window:* zoom of the left window, 2.5×2.5 arcmin² field of view. *AVAILABLE only in ApJ.*

Fig. 3.— Same as left window in Fig. 2, but for the system HD 221356 + 2M2331–04AB (Koenigstuhl 3 A–BC). Epochs are separated by 48.3 years. *AVAILABLE only in ApJ.*